VARIABLE

BAND-PASS FILTER

OPERATING AND MAINTENANCE MANUAL

Model 310-AB (R) -8

SERIAL NO. 2817

KROHN-HITE CORPORATION

580 Massachusetts Ave., Cambridge 39, Mass., U.S.A.

MODEL 310-ABR-8

The electrical specifications for the Model 310-ABR-8 are the same as those for the Standard Model 310-ABR except that the cut-off frequency calibration is 5%.

The Model 310-ABR-8 differs from the Standard Model 310-ABR in certain ways:

1) The height of the instrument has been reduced: the front panel is only 5 1/4 " high.
2) The power transformer primary is not wired for optional 115/230 V operation: it is wired for 115V only.
3) BNC type connectors replace the front panel GR type. Another set of BNC connectors is mounted in the rear of the chassis (standard equipment).
4) The front panel is painted with Fed. Std. 595 color #27875 paint and the panel marking is black silk screening.
5) Additional components are used (shown on the modified schematic attached to the rear of this manual).
6) Values of some components are changed: some components have been placed into different configurations (also shown on modified schematic).

THE ABOVE CHANGES AND DIFFERENCES MAY BE INCORPORATED IN THE INSTRUCTION MANUAL AT THE DISCRETION OF THE CUSTOMER.

KROHN-HITE CORPORATION
580 Massachusetts Ave.,Cambridge 39,Mass.

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_08630

TABLE OF CONTENTS

Page

SECTION I - GENERAL DESCRIPTION

1. Technical Summary 4
2. Description 6

SECTION II - DETAILED SPECIFICATIONS

1. Accuracy of Cut-off Frequency Calibration 7
2. Insertion Loss 7
3. Attenuation Slope 7
4. Output Impedance 8
5. Internally Generated Hum and Noise 8
6. Filter Characteristics 8
7. Minimum Pass Band 9
8. Distortion 9
9. Transient Response 9

SECTION III - THEORY OF OPERATION 13

SECTION IV - CIRCUIT DESCRIPTION

1. Power Supply 17
2. Input Amplifier A1 17
3. Cathode Followers A3 and A5 17
4. Cathode Followers A6, A7 and A8 17
5. Cathode Follower A9 17
6. Cathode Followers A3 and A4 17

SECTION V - MAINTENANCE

1. Tube Complement Check 18
2. Fuse Failure 18
3. Power Supply 19
4. Input Amplifier A1 19
5. Remaining Stages 20
6. Signal Tracing Analysis 21
7. Tuning Circuits 21

SECTION VI - CALIBRATION AND ADJUSTMENT 22

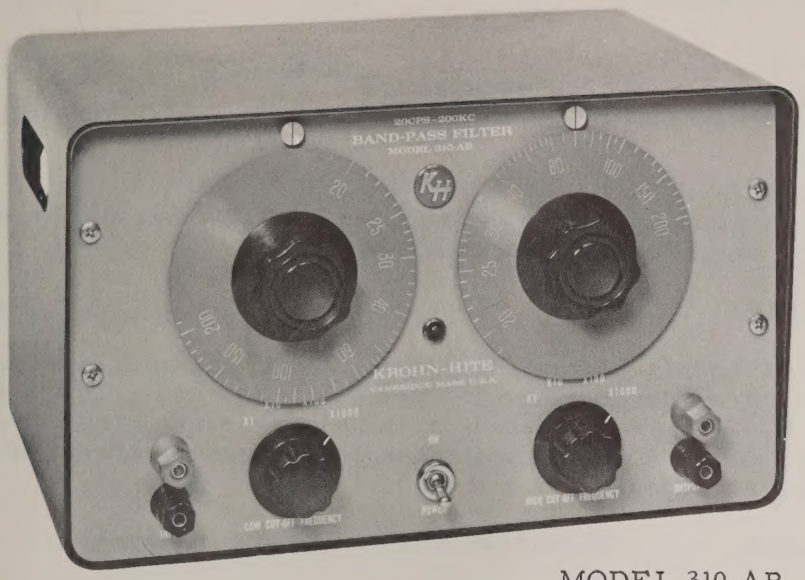
SECTION VII - SERVICE AND WARRANTY 37

SECTION VIII - PARTS LIST 38

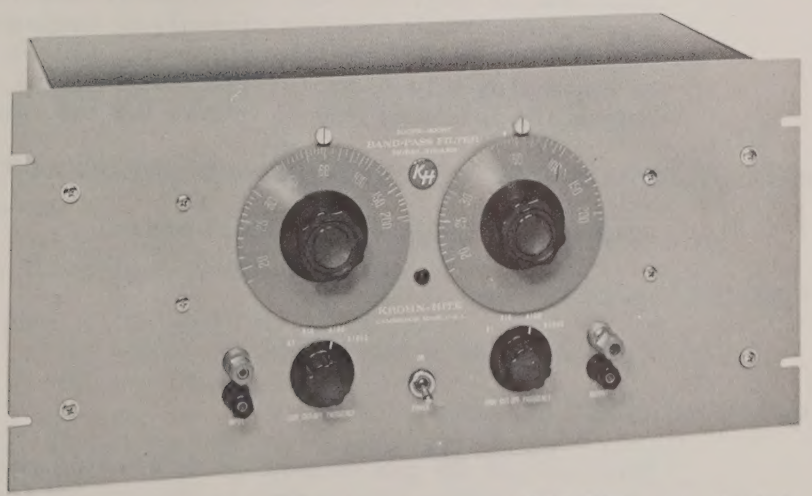
LIST OF ILLUSTRATIONS

Figure

1. Model 310-AB(R) Variable Band-Pass Filter 3
2. Typical Normalized Pass-Band Characteristics 10
3. Modified Cut-off Frequency Gain 11
4. Typical Normalized Attenuation Characteristics 11
5. Typical Normalized Pass-Band Characteristic - Narrow-Band Operation 12
6. Typical Normalized Phase Characteristics 12
7. Fundamental Circuit of One High Cut-off Section 13
8. Effect on Corner Peaking Caused by Changing G_{co} 14
9. Fundamental Circuit of One Low Cut-off Section 14
10. Effect of Corner Peaking 15
11. Phase and Amplitude Characteristics 16
12. Block Diagram of Model 310-AB(R) 16
13. Test Point Voltages 21
14. Rear View of Tuning Potentiometer Panels 22
15. Table of HCO and LCO Potentiometer Resistance Measurements 23
16. Table of Trim Resistor Adjustments for Tuning Potentiometer 24
17. Detailed Test Procedure 26
18. Schematic Diagram . . . . . Inside Back Cover
19. Voltage and Resistance Measurements . . . . Inside Back Cover



MODEL 310 AB



MODEL 310 AB(R)

Figure 1 - MODEL 310-AB AND MODEL 310-ABR VARIABLE BAND PASS FILTER

1. TECHNICAL SUMMARY

TYPE:

Band-Pass.

BAND WIDTH:

Continuously variable up to the maximum width covering the entire frequency range from 20 cps to 200 kc.

FREQUENCY RANGE:

Continuous coverage from 20 cps to 200 kc for both high cut-off and low cut-off frequencies independently; frequency range is covered by separate calibrated dials and four-decade band switches; center frequency and width of pass band continuously adjustable within the above frequency range.

Band	Multiplier	Frequency (cps)
1	1	20 - 200
2	10	200 - 2,000
3	100	2,000 - 20,000
4	1,000	20,000 - 200,000

FREQUENCY DIALS:

Each dial is engraved and individually hand calibrated with a single logarithmic scale reading directly in cycles per second from 19 to 210; dials are 4 inches in diameter with an effective scale length of approximately 8 inches per band giving a total effective scale length of approximately 32 inches for the range of 20 cps to 200 kc.

*ACCURACY OF CUT-OFF FREQUENCY CALIBRATION:

±10% (±5% available on special order).

*INSERTION LOSS:

Zero db ±1 db in pass band.

*ATTENUATION SLOPE:

Nominal 24 db per octave each side of pass band with peaking factor to reduce attenuation at the cut-off frequencies.

*For additional data refer to corresponding heading under SECTION II - DETAILED SPECIFICATIONS.

MAXIMUM ATTENUATION:

Greater than 60 db.

INPUT CHARACTERISTICS:

IMPEDANCE: Approximately 6 megohms in parallel with 50 uuf.
MAXIMUM INPUT AMPLITUDE: 5 volts rms.
MAXIMUM DC COMPONENT: 400 volts.

OUTPUT CHARACTERISTICS:

*IMPEDANCE: Approximately 500 ohms.
*MAXIMUM POWER: 2.5 volts rms across 500 ohms or 12 milliwatts.
*INTERNALLY GENERATED HUM AND NOISE: Less than 0.2 millivolt.

CONTROLS:

LOW CUT-OFF FREQUENCY dial and multiplier switch.
HIGH CUT-OFF FREQUENCY dial and multiplier switch.
POWER OFF-ON switch.

TERMINALS:

Two multi-purpose binding posts for the INPUT and two for the OUTPUT.

POWER REQUIREMENTS:

105-125 volts; single phase; 50-60 cycles; 55 watts.

FUSE PROTECTION:

1 ampere slow-blow.

TUBE COMPLEMENT (furnished with instrument):

6-12AT7, 1-6BK7-A, 1-6AU5-GT, 1-6X5-GT.

FORM:

Furnished in a cabinet. Over-all dimensions Model 310-AB: 12" wide, 7" high, 8" deep. Weight 17 lbs. net, 19 lbs. shipping. Rack mounting available, Over-all dimensions Model 310-ABR: 19" wide, 8-3/4" high, 7-1/2" deep. Weight 21 lbs. net, 24 lbs. shipping.

*For additional data refer to corresponding heading under SECTION II- DETAILED SPECIFICATIONS.

2. DESCRIPTION

The Model 310-AB(R) is a variable electronic band-pass filter whose gain is unity in the pass band and drops outside the pass band at a rate of 24 db/octave. Both the high and low cut-off frequencies are independently adjustable from 20 cps to 200 kc. This provides maximum flexibility of adjustment of both the band center frequency and the band width. Two identical frequency dials and multiplier switches are used for the two cut-off frequencies. Each dial is single scale, direct reading, and engraved logarithmically from 19 to 210. The associated multiplier switch selects one of the four decade bands.

The filter consists of a variable high-pass section and a variable low-pass section connected in series. Each section contains four cascaded resistance-capacitance elements coupled by isolating stages. Since the rate of attenuation of each RC element is 6 db/octave, the net attenuation rate of each section is 24 db/octave. The use of input and output buffer stages provides a high impedance input and a low impedance output.

The transfer function of the filter is approximately:

$$\frac{\omega^4 T_1^4}{[(1 + 2jA\omega T_1 - \omega^2 T_1^2)^2] \quad [(1 + 2jA\omega T_2 - \omega^2 T_2^2)^2]}$$

where the low cut-off frequency is $1/(2\pi T_1)$ and the high cut-off frequency is $1/(2\pi T_2)$. The value of the peaking factor, "A", which is normally unity for filters composed of independent resistance-capacitance elements, is fixed at slightly greater than 0.6. This value produces approximately 1 db peaks in the gain vs. frequency plot, but reduces the attenuation at the corner frequencies by approximately 9 db and permits a band width as narrow as one octave with very little attenuation in the center of the pass band. For most applications the performance is better than that of a 24 db filter with unity peaking factor because with the same attenuation outside the pass band, the gain near the corner frequencies is greater.

The Model 310-AB(R) is especially useful in the audio and ultrasonic frequency range for noise measurements, harmonic and frequency analysis of audio instruments, also for psycho-acoustics and electro-medical research.

SECTION II - DETAILED SPECIFICATIONS

1. ACCURACY OF CUT-OFF FREQUENCY CALIBRATION

The high and low cut-off frequencies, as defined below, will be within ±10% of the corresponding dial reading. KROHN-HITE Electronic Filters are calibrated to conform to each of the following definitions:

a. Cut-off frequency can be defined as the frequency which is the reciprocal of $2\pi T$ in the filter transfer function. At this frequency the phase shift through either the high-pass or the low-pass filter section alone is exactly 180 degrees.

b. Cut-off frequency is also the frequency at which the extension of the straight portion of the filter attenuation slope (24 db per octave) intersects the extension of the pass band gain characteristic. If the attenuation rate should differ from 24 db per octave (see ATTENUATION SLOPE below) this method of determining the cut-off frequency is not valid.

c. From passive filter terminology the cut-off frequency is the frequency at which the output of the filter is 3 db down from the output at the middle of the pass band.

When checking the cut-off frequency calibration accuracy as defined in (c) above, refer to Figure 3. Cut-off frequency gain is the amount by which the filter output at the cut-off frequency differs from the mid-band or mean frequency output. This gain varies with separation of the cut-off frequencies (see FILTER CHARACTERISTICS) and it is plotted in Figure 3 as a function of the ratio of high to low cut-off frequencies. Cut-off frequency gain approaches minus 3 db for wide separations (curve A of Figure 2) has a maximum of about minus 4.2 db for a factor of four separation (curve C of Figure 2) and goes to zero db when the cut-off frequencies coincide.

2. INSERTION LOSS

The filter output voltage under open circuit conditions will be within 1 db (±1 db) of the input voltage for all frequencies within the pass band. The pass band, for the purpose of specifying insertion loss, is defined as the frequency spectrum from ten times the low cut-off frequency setting to one tenth of the high cut-off frequency setting. To determine the insertion loss (pass band gain) accurately, the high and low cut-off frequencies must be at least a factor of one hundred apart, and the measuring frequency must be the geometric mean of these frequencies. Note that in all cases Figures 2, 3, 4, 5 and 6 show a reference output level. The reference output level can be readily converted to input level once the pass band gain has been determined exactly for a particular instrument.

3. ATTENUATION SLOPE

A typical attenuation curve is shown in Figure 4. At the cut-off frequency the slope is approximately 12 db per octave and at the 12 db point the slope has essentially reached its nominal value of 24 db per octave.

The slope of the straight portion of the curve may be slightly less than 24 db per octave at certain frequencies because of cross-coupling effects, and at the extreme ends of the frequency range this slope may exceed 24 db per octave because of the fall-off in internal amplifier gain which adds to the normal attenuation.

4. OUTPUT IMPEDANCE

The rated output impedance is the source impedance and is also the minimum load that may be connected to the filter. For this value of load the insertion loss will be approximately 6 db. Lower values of load resistance will not damage the instrument but will increase the distortion. Higher values of external load may be used with no sacrifice in performance and correspondingly lower insertion loss. In the case of these instruments there is no requirement that the load impedance match the output impedance.

5. INTERNALLY GENERATED HUM AND NOISE

This specification is based on the use of a Ballantine Model 310 Voltmeter, or equivalent. This measurement is made with the INPUT terminals connected together by a low impedance shorting jumper, no other external signal connections to the instrument and the voltmeter leads shielded.

6. FILTER CHARACTERISTICS

Several normalized filter characteristics are shown in Figure 2 for different settings of the cut-off frequencies.

Peaking circuits, which are used to sharpen the corners of the pass band characteristic, introduce gain peaks in the pass band approximately one octave above the low cut-off frequency and one octave below the high cut-off frequency. Curves A and B of Figure 2 show gain peaks of about 0.75 db. When the cut-off frequencies are set approximately two octaves apart (a factor of four), the peaks coincide causing a further increase in the gain peak. Curve C of Figure 2 shows a gain peak of about 1.5 db. The improvement in the filter characteristic effected by the corner peaking circuits is shown by the difference between curves A and B of Figure 4.

The typical pass band characteristic for any cut-off frequencies can be plotted from curve C of Figure 4, since the gain at any frequency is the sum of the gains due to both the high and low cut-off filter sections. For example, consider the case mentioned above of high and low cut-off frequency separation of a factor of four. The high cut-off frequency is represented by 1 on the f/f_H scale, the mean frequency is at 0.5 on this same scale, and the curve shows a gain value of 0.75 db. The low cut-off frequency is represented by 1 on the f_L/f scale, the mean frequency is at 0.5 on this scale and a second gain of 0.75 db is shown. The net gain at the mean frequency is 1.5 db with respect to the normal pass band gain.

At the high cut-off frequency there will be a loss of 3 db due to the high cut-off section, represented by 1 on the f/f_H scale, and a gain of 0.3 db from the low cut-off section, shown at 0.25 on the f_L/f scale. Gain at both the high and low cut-off frequencies is minus 2.7 db because the curve is symmetrical about the mean frequency. As many more points as required may be determined in a similar manner.

7. MINIMUM PASS BAND

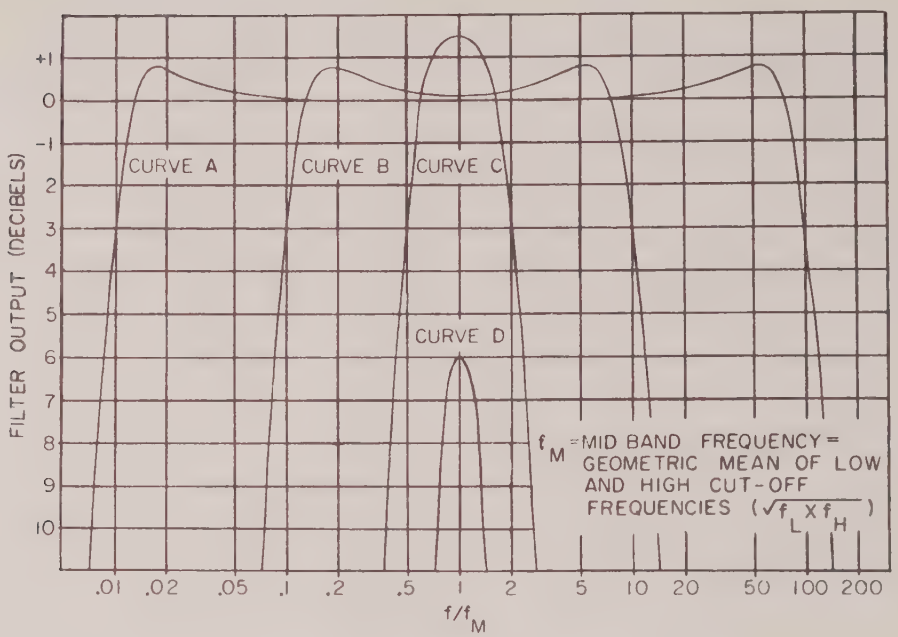
Minimum pass band width is obtained by setting the high and low cut-off frequencies equal. In this case, the lower 3 db point is at 0.77 times the cut-off frequency; the upper 3 db point is at 1.30 times the cut-off frequency, and the insertion loss is 6 db. See Figure 5. Crossing over the high and low cut-off frequencies increases the pass band width and at the same time increases the insertion loss.

8. DISTORTION

Filter distortion is a function of several variables and is difficult to specify exactly. In general, if the filter is operated within its ratings, distortion products introduced by the filter and not present in the INPUT signal will not exceed 0.5% of the OUTPUT signal. In most cases distortion will be considerably less than 0.5%.

9. TRANSIENT RESPONSE

This term is sometimes used in reference to filters in an attempt to specify performance when impulse voltages are applied to the filter input. Mathematical analysis and laboratory measurements show that for a given input signal (complex wave, square wave, step function, etc.) all filters will produce an output signal which depends only on the transfer function vs. frequency and is not affected in any manner by the electrical composition of the filter (RC, m-derived, etc.). The phase and/or amplitude of the individual input signal frequency components may, however, suffer undue distortion at the output if the filter does not have a smooth transfer characteristic with no pronounced peaks. Distortion of this nature is minimized by the design of KROHN-HITE Filters. These filters represent the optimum practical approach to ideal filter characteristics combined with versatility to give unsurpassed performance.



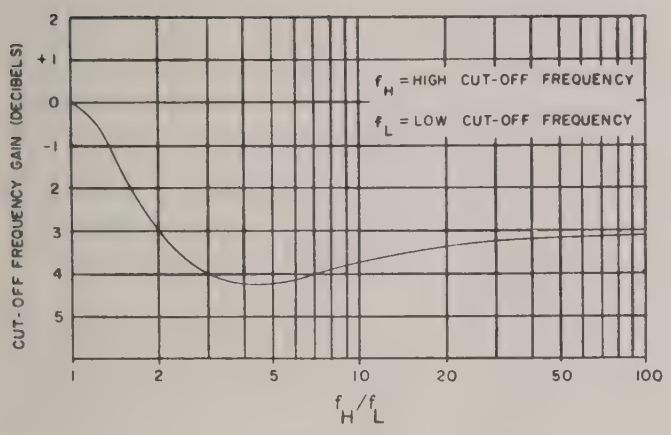
Curve A - High and low cut-off frequencies separated by a factor of 10,000. Note that the filter gain (insertion loss) through the middle of the pass band is shown as zero db. This is an arbitrary reference level and can vary plus or minus one db from the input signal when there is no load on the filter output.

Curve B - Interaction of high and low cut-off peaking circuits increases mid-band gain by approximately 0.1 db when the cut-off frequency separation is reduced to a factor of 100.

Curve C - Mid-band gain increased by approximately 1.5 db when high and low cut-off frequency separation is reduced to a factor of 4.

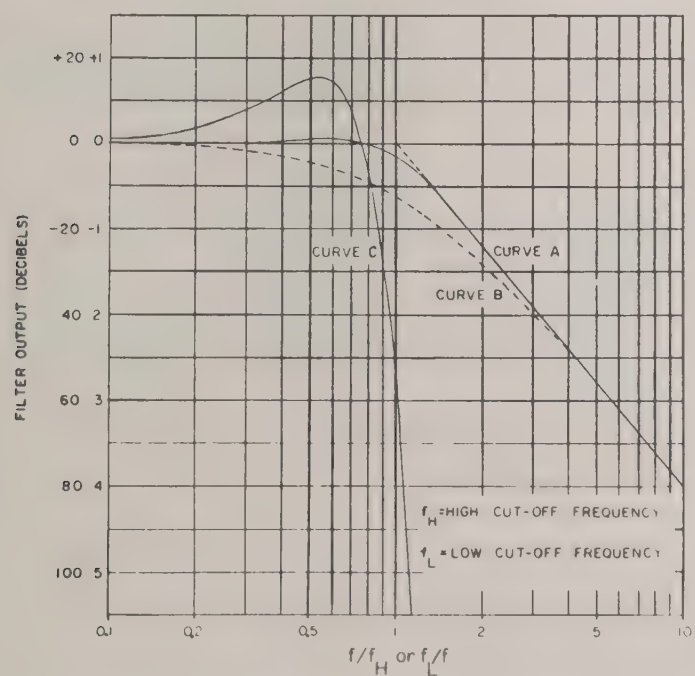
Curve D - Minimum pass band width is obtained by setting the cut-off frequencies equal. Gain at the peak of the pass band is reduced by approximately 6 db. Refer to Figure 5.

Figure 2 - TYPICAL NORMALIZED PASS BAND CHARACTERISTICS



Cut-off frequency gain values from this curve must be used in order to check calibration of the filter accurately when high and low cut-off frequency separation is less than a factor of 100. Cut-off frequency gain is the amount by which the filter output at the cut-off frequency differs from the mid-band or mean frequency output. See 1. c. ACCURACY OF CUT-OFF FREQUENCY CALIBRATION.

Figure 3 - MODIFIED CUT-OFF FREQUENCY GAIN

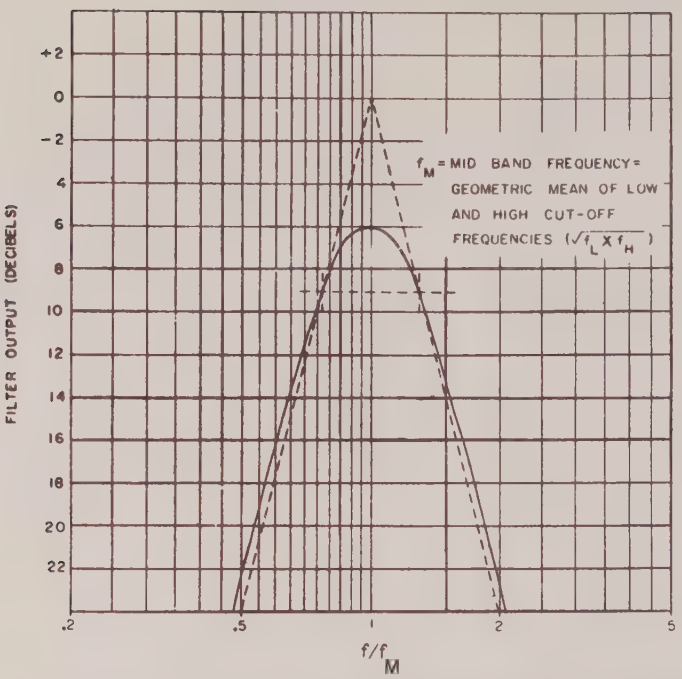


Curve A - Attenuation characteristic shown to the minus 80 db level.

Curve B - Attenuation characteristic obtained without corner peaking circuits.

Curve C - Pass-band characteristic near the cut-off frequency (unity) shown on expanded db scale.

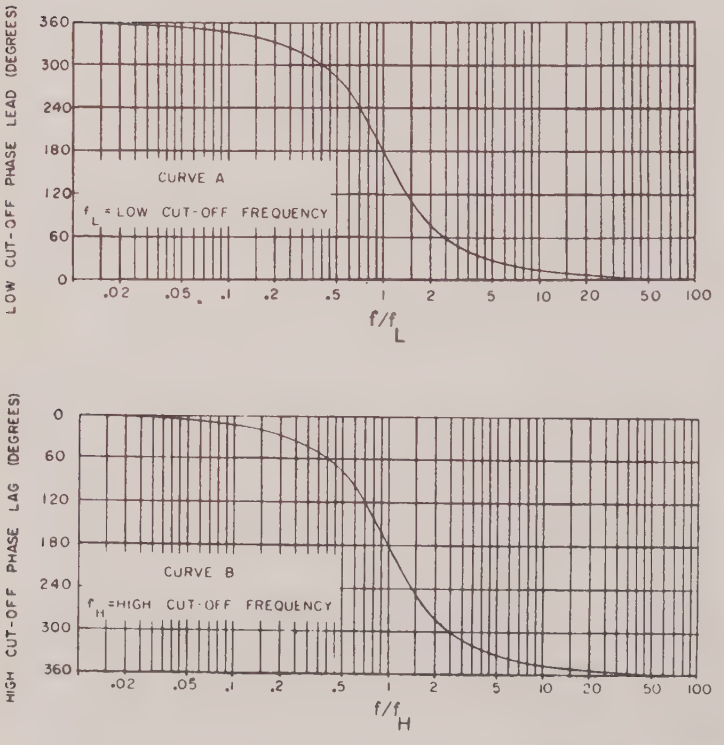
Figure 4 - TYPICAL NORMALIZED ATTENUATION CHARACTERISTICS



Filter pass-band characteristic for minimum band-width setting. High and low cut-off frequencies are equal (unity) and insertion loss at the peak of the pass band is 6 db. The 3 db down points, measured from the peak, occur at 0.77 and 1.30 times the cut-off frequency.

Dash lines are extensions of the 24 db per octave slope which intersect the output signal reference level at the cut-off frequency.

Figure 5 - TYPICAL NORMALIZED PASS BAND CHARACTERISTIC - NARROW BAND OPERATION



Phase shift introduced by the low and high cut-off filter sections is shown by Curves A and B respectively where the cut-off frequencies are represented by unity on the normalized frequency scale. Total phase shift through the filter at any frequency is the sum of the phase shifts of the low and high cut-off sections at that frequency. Phase lag is considered to have a negative sign and a phase lead a positive sign.

Figure 6 - TYPICAL NORMALIZED PHASE CHARACTERISTICS

SECTION III - THEORY OF OPERATION

The basic circuit of one of the high cut-off sections of the filter is shown in Figure 7.

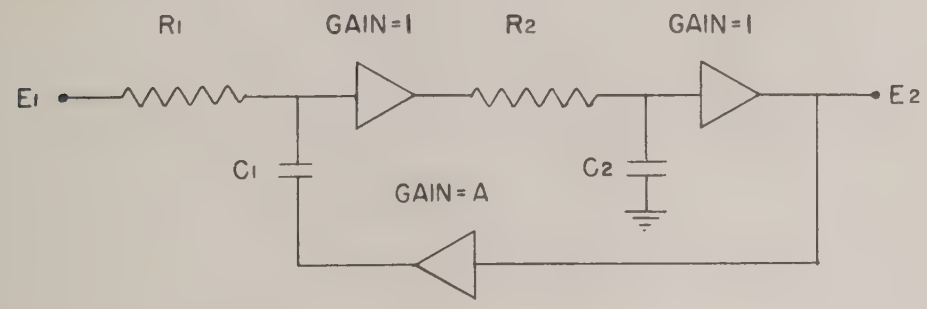


Figure 7 - FUNDAMENTAL CIRCUIT OF ONE HIGH CUT-OFF SECTION

This basic circuit consists of two high cut-off RC sections coupled by unity gain buffer amplifiers. A feedback signal of AE_2 is fed back to the first capacitor. If both capacitors are the same, this circuit has a transfer characteristic of:

$$\frac{E_2}{E_1} = \frac{1}{j^2\omega^2 (R_1C\ R_2C) + j\omega\ [R_2C + (1\text{-}A)R_1C] + 1}$$

At the cut-off frequency where:

$$j^2\omega^2 R_1C\ R_2C + 1 = 0 \text{ and } \omega_{co} = 1/\sqrt{R_1CR_2C}$$

The gain of the circuit is:

$$G_{co} = \frac{1}{\sqrt{R_2/R_1} + (1\text{-}A)\sqrt{R_1/R_2}}$$

Thus the G_{co} can be controlled by adjusting "A" and the ratio R_2/R_1. The peaking of the response curve for three different values of G_{co} is shown in Figure 8.

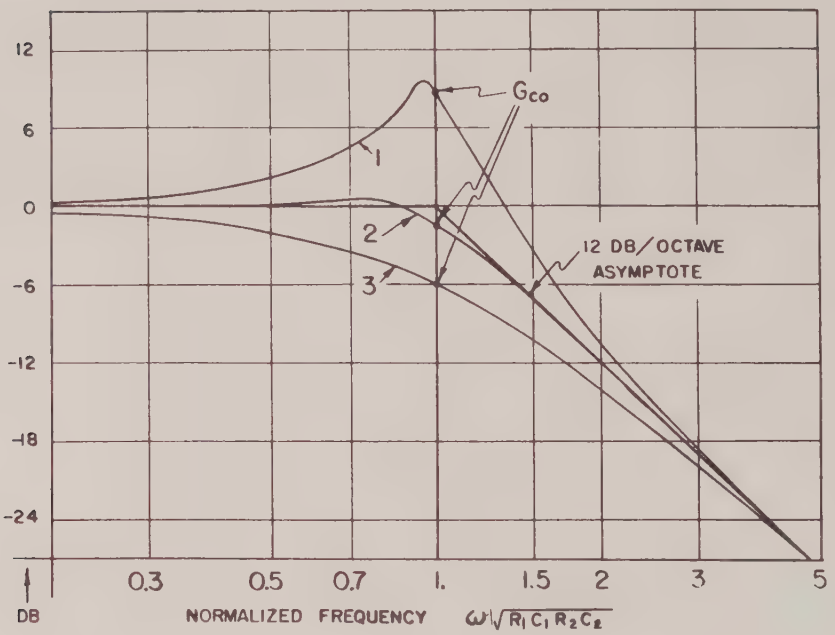


Figure 8 - EFFECT ON CORNER PEAKING CAUSED BY CHANGING G_{co}

Curve 2 is the one used in the filter and is achieved by setting $A = 0.92$ and $R_2/R_1 = 1.06$ giving a G_{co} for one 12 db/octave section of approximately minus 1.5 db. The basic circuit of one of the low cut-off sections of the filter is shown in Figure 9.

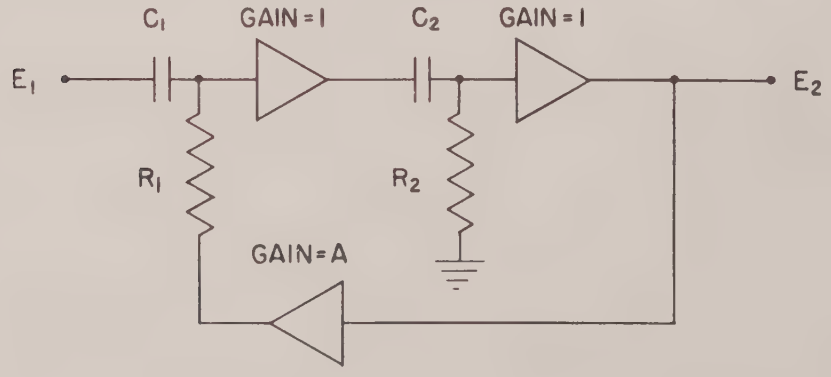


Figure 9 - FUNDAMENTAL CIRCUIT OF ONE LOW CUT-OFF SECTION

The equations for this circuit are:

$$\frac{E_2}{E_1} = \frac{j^2\omega^2 R_1C\ R_2C}{j^2\omega^2 R_1C\ R_2C + j\omega\ [R_1C + (1\text{-}A)R_2C] + 1}$$

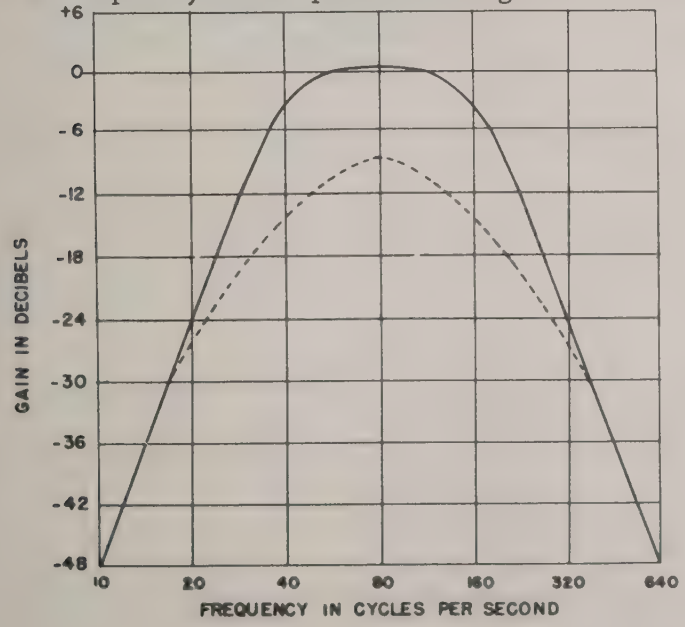
$$\omega_{co} = 1/\sqrt{R_1C\ R_2C}$$

$$G_{co} = \frac{1}{\sqrt{R_1R_2} + (1\text{-}A)\sqrt{R_2/R_1}}$$

The response curves for this circuit come out symmetrical with those if Figure 8 about the $\omega = 1.0$ axis. Again, curve 2 is the one used in the filter and is achieved by setting $A = 0.92$ and $R_1/R_2 = 1.06$.

The whole filter consists of two high cut-off sections and two low cut-off sections, giving a total peak of 0.75 db and a total G_{co} of minus 3 db and a total slope of 24 db per octave at both ends of the pass band. This choice of peaking results in only a small (0.75 db) peak in the curve, but reduces the corner frequency attenuation by 9 db from that obtained from four independent RC sections.

For most applications, the Model 310-AB is superior to a 24 db filter with independent RC sections, because with the same attenuation outside the pass band, the gain near the corner frequencies is greater. Figure 10 shows the response of the Model 310-AB (solid curve) and of a similar filter with independent RC sections (dash curve). The low cut-off frequency is 40 cps and the high cut-off frequency is 160 cps.



Solid curve shows the Band-Pass response of the Model 310-AB. Dash curve is the response of a similar filter with independent RC sections.

Figure 10 - EFFECT OF CORNER PEAKING

Phase characteristics are shown in Figure 11. The total phase characteristic is found by adding the two separate phase curves together.

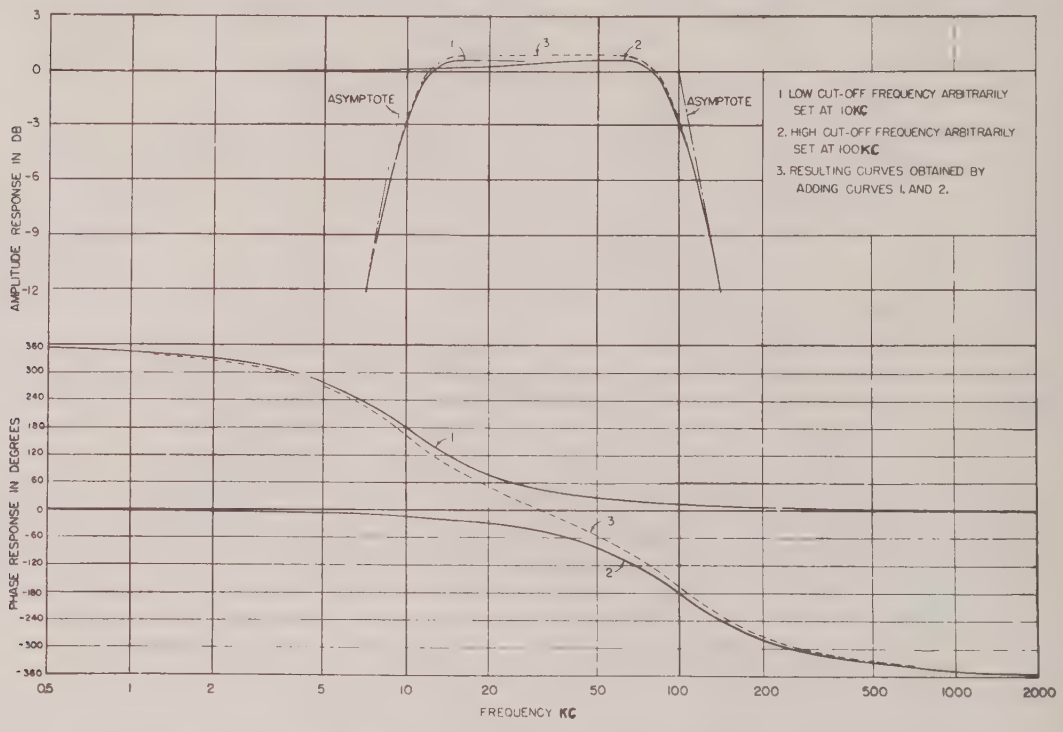


Figure 11 - PHASE AND AMPLITUDE CHARACTERISTICS

For a narrow pass band, both dials may be set at the same frequency ω. The peak will occur at ω, 6 db down from the input. The points 3 db down from the peak will occur at 0.77ω and 1.30ω. 2ω and 3ω will be 16 db and 28 db down from the peak respectively.

SECTION IV - CIRCUIT DESCRIPTION

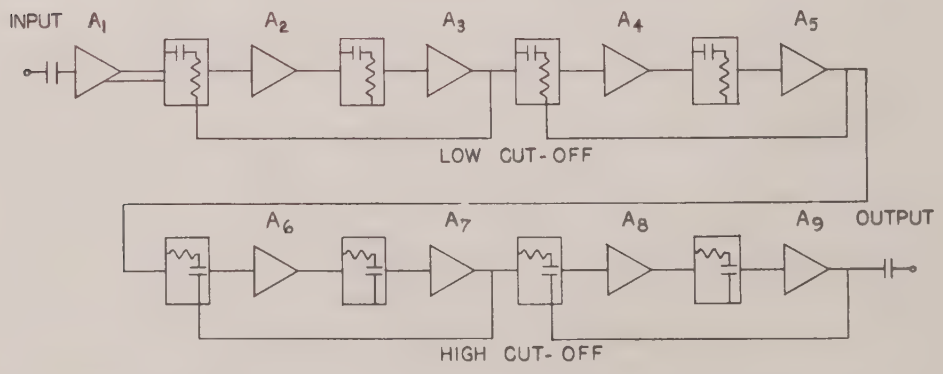


Figure 12 - BLOCK DIAGRAM OF THE MODEL 310-AB(R)

SECTION IV - CIRCUIT DESCRIPTION

1. POWER SUPPLY

The power supply employs a standard full-wave rectifier and pi-filter in conjunction with a series regulator circuit. In the regulator, any small change in B+ is amplified by V2B and then fed to the regulator tube V7. This amplified signal changes the bias and consequently the resistance of V7 in such a manner as to counteract the original change in B+. The regulator further reduces the output noise of the 310-AB(R), especially that which is caused by line voltage fluctuations.

2. INPUT AMPLIFIER (A1 Figure 12)

This amplifier supplies a low impedance driving source to the RC circuits following it and supplies extra gain to make up for the cathode follower losses. It is a three-stage feedback amplifier with two low-impedance outputs having gains of 1.3 and 3.3.

A fraction of the output signal is tapped off at the junction of R11 and R12 and is fed back to the cathode of V1 (pin 3) where it is compared to the input signal. The amplifier is partially direct coupled and partially RC coupled for maximum stability.

Due to the highly variable nature of the RC loads, several different types of cathode follower are used to obtain minimum distortion and maximum load handling ability while maintaining high tube efficiency.

3. CATHODE FOLLOWERS A3 and A5

Since these RC circuits do not require as much driving power, a single stage cathode follower is used in the interest of over-all instrument efficiency.

4. CATHODE FOLLOWERS A6, A7 and A8

Slightly more power is demanded from these cathode followers: hence a more powerful 6BK7A and 12AT7 single-stage circuit is used.

5. CATHODE FOLLOWER A9

Since still more power is demanded from this output cathode follower, a smaller cathode resistor is used in the circuit.

6. CATHODE FOLLOWERS A3 and A4

These two-stage cathode followers are used in critical parts of the circuit and each may be viewed as a two-stage RC coupled amplifier with feedback from the second plate to the first cathode.

SECTION V - MAINTENANCE

All components in the Model 310-AB(R) are of the highest quality and should have a long trouble-free life since they are operated well below their manufacturers' ratings. The following procedure should facilitate locating the source of trouble if the 310-AB(R) does not function properly.

To take the chassis out of the cabinet, remove the two lower innermost screws from the rear plate and slide the chassis out from the front.

1. TUBE COMPLEMENT CHECK

Before any maintenance procedure, turn on the 310-AB(R) and then check to make certain that the correct tubes are inserted properly in their respective sockets as shown in the top view in Figure 18. At the same time, note if the filaments of the tubes are lit. If any of the filaments fail to light after sufficient warm up time, replace the tube.

If the above procedure produces no results, the likeliest source of failure is the vacuum tubes since they have an inherently shorter life. Obtain appropriate new tubes and then, one at a time, substitute the new tube in each position in the 310-AB(R) where it is used. The type number of each tube is clearly marked on the chassis adjacent to the tube.

2. FUSE FAILURE

A one-ampere cartridge fuse, located in the back of the chassis, is used in the primary circuit of the power transformer to protect the power supply components from short circuit. The rating of this fuse was selected for proper protection of the instrument and the fuse should only be replaced with one of the same type and rating.

If a fuse failure is detected, the following procedure is recommended before replacing the fuse:

a. Remove the 6X5 rectifier tube, V6, and disconnect the power cord. Measure the dc primary resistance of the power transformer which should be 5 ohms. A lower resistance indicates a shorted primary.

b. Insert a new fuse, connect the power, and then, with the 6X5 still out, check the primary and the secondary voltages of the transformer. If the voltages are correct, the transformer is functioning properly.

c. Prior to inserting a new 6X5 rectifier tube, disconnect the power and check the dual 40 uf filter capacitor, C26. A shorted capacitor can be detected by connecting an ohmmeter (low range) across it directly. If these capacitors are not shorted, check the regulated and unregulated B+ to determine if they are shorted to each other or individually to ground. The unregulated B+ can be located conveniently at pin 5 of V7. The regulated B+ can be checked at pin 1 of V2.

d. If the above procedure has not uncovered any faulty components or wiring, the rectifier tube may be the cause of the trouble and should be replaced.

In most cases, the above procedure will uncover the cause of a fuse failure. However, occasions arise when unusual defects occur such as intermittent shorts in components and tubes and short circuits resulting from foreign particles. These, unfortunately, are beyond the scope of this maintenance procedure.

3. POWER SUPPLY

If the 310-AB(R) is not functioning when the rated line voltage is applied and the instrument is powered as indicated by the pilot light or visible tube filaments, it is advisable to check the power supply.

The plus 360 volt unregulated supply voltage, as derived from the cathode of the rectifier tube V6, is filtered in a capacitor input single-section pi-filter consisting of C26 and L1. The unregulated voltage should be checked at rated line voltage.

If the unregulated voltage deviates from its proper value, replace the rectifier V6. When replacing V6 brings about no change in the voltage level, check the total current drain by measuring the voltage across L1 which, under normal conditions, should measure 27 volts. If the voltage is appreciably higher than normal, the 310-AB is drawing excessive current. The excess current may be due to a low resistance path which may occur in the dual 40 uf filter capacitor C26 or in the filter when the dc output levels of any of the amplifiers are incorrect.

Since both stages of the ac regulator are RC coupled, their dc levels are independent so that the voltage levels of each stage can be checked independently according to the voltage chart, Figure 19. Too large a voltage drop across V7 suggests too much grid bias which could be caused by a leaky C28. The voltage at V2 pin 6 may vary quite a bit since this tube derives its bias from grid current which varies from tube to tube.

4. INPUT AMPLIFIER A1

Due to RC coupling from V1A plate, pin 1, to V1B grid, pin 7, there is no dc feedback and the dc levels are determined as follows:

V1B grid, pin 7, is at 0 volts.

R7 and R8 set the voltages of V1B plate and cathode, pins 6 and 8.

Voltage at V1B plate, pin 6, appears on V2A grid, pin 2 (no current flows through parasitic suppressor R9).

Voltage at V2A cathode, pin 3, should be only a few volts more positive than V2A grid, pin 2, due to cathode follower action.

Voltage at V1A cathode, pin 3, is set by the voltage at V2A cathode, pin 3, voltage divider R10-R11, resistor R12, and the current drawn by V1A.

Voltage at V1A plate, pin 1, is determined by voltage at V1A cathode, pin 3, R4 and R3.

If the voltages are checked in this order, a malfunction in the input amplifier can be most easily tracked down.

5. REMAINING STAGES

All of the remaining stages are types of cathode followers. Stages A2 and A4 can be considered as cathode followers by considering the bottom tube to be a simple dc resistance.

In all cases, due to cathode follower action, the cathode of each stage will be a few volts higher than the grid of the same stage if the circuit is working properly. Also, there should be no voltage change in going from the cathode of one stage to the grid of the next direct-coupled stage. The cathode followers are coupled in the following order:

R22 and R23 set the voltage at V4A grid, pin 2.

Cathode follower action sets V4A cathode, pin 3, a few volts higher.

This voltage on pin 3 is divided down by R25 and R26 and is used to set the level of V3 grid, pin 7. Due to cathode follower action, this also sets the level of V3, pins 8 and 1.

R36 and R37 set the voltage at V4B grid, pin 7.

Cathode follower action sets V4B cathode, pin 8, a few volts higher.

This voltage on pin 8 is divided down by R39 and R40 and is used to set the level of V5 grid, pin 2, and, as above, the level of V5 pins 3 and 6.

The voltage on pin 8 of V4B is also fed to V8A grid, pin 2, which, as above, sets the level of V8A cathode, pin 3.

The voltage at V8A cathode, pin 3, is fed to V8B grid, pin 7, which, as above, sets the voltage of V8B cathode, pin 8.

R61 and R63 set the voltage at V9A grid, pin 2, which, as above, sets the voltage of V9A cathode, pin 3, a few volts higher.

The voltage at V9A cathode, pin 3, is fed to V9B grid, pin 7, which, as above, sets the voltage of V9B cathode, pin 8.

Any break in these chains of slowly rising voltage from grid to cathode to grid to cathode indicates that that stage, or its associated circuitry, is malfunctioning and should be carefully checked.

6. SIGNAL TRACING ANALYSIS

Apply a 2,000 cps 5 volt rms sine wave to the INPUT of the filter. Set the LOW CUT-OFF FREQUENCY to 20 cps and the HIGH CUT-OFF FREQUENCY to 200 kc. When the filter is operating properly this 2,000 cps test signal will pass through the filter unchanged and appear at the OUTPUT with equal amplitude. If the test signal does not appear at the OUTPUT of the filter it is advisable to first localize the malfunction by determining where the test signal fails to appear within the filter.

Test points in the filter with their correct signal voltages are listed below in Figure 13 for a 5 volt rms sine wave input. If the test point voltage differs appreciably from the correct voltage, all of the components, wiring and voltage and resistance readings to ground associated with the tube(s) preceding the test point should be checked.

TEST POINT TUBE NO.	PIN NO.	CORRECT SIGNAL VOLTAGE MODEL 310-AB(R)
V1	1	0.8v
V1	6	20.0
V2	3	20.0
V3	8	6.4
V4	3	6.2
V5	3	6.2
V4	8	6.0
V8	3	5.8
V8	8	5.5
V9	3	5.2
V9	8	5.0

LOW CUT-OFF AT 20 CPS;
HIGH CUT-OFF AT 200 KC;
2,000 CPS: - 5 VOLTS RMS INPUT

Figure 13 - TEST POINT VOLTAGES

7. TUNING CIRCUITS

The tuning capacitors are switched four at a time by the band switches as shown in the schematic diagram Figure 18.

The tuning resistances are varied by the tuning dial which turns four potentiometers through a system of gears. The trim resistors and angular orientation of these potentiometers are carefully adjusted at the factory for proper tracking and tuning. No attempt should be made to replace the potentiometers since such replacement would require calibrating a new dial. The trim resistors can be replaced after repair according to instructions in the detailed test procedures (see Figure 16) of Section VI.

SECTION VI - CALIBRATION AND ADJUSTMENT

1. ALIGNING FILTER TUNING POTENTIOMETER ASSEMBLIES

Figure 14A shows the rear view of the HCO (high cut-off) frequency tuning potentiometer panel, and Figure 14B shows the rear view of the LCO (low cut-off) frequency tuning potentiometer panel.

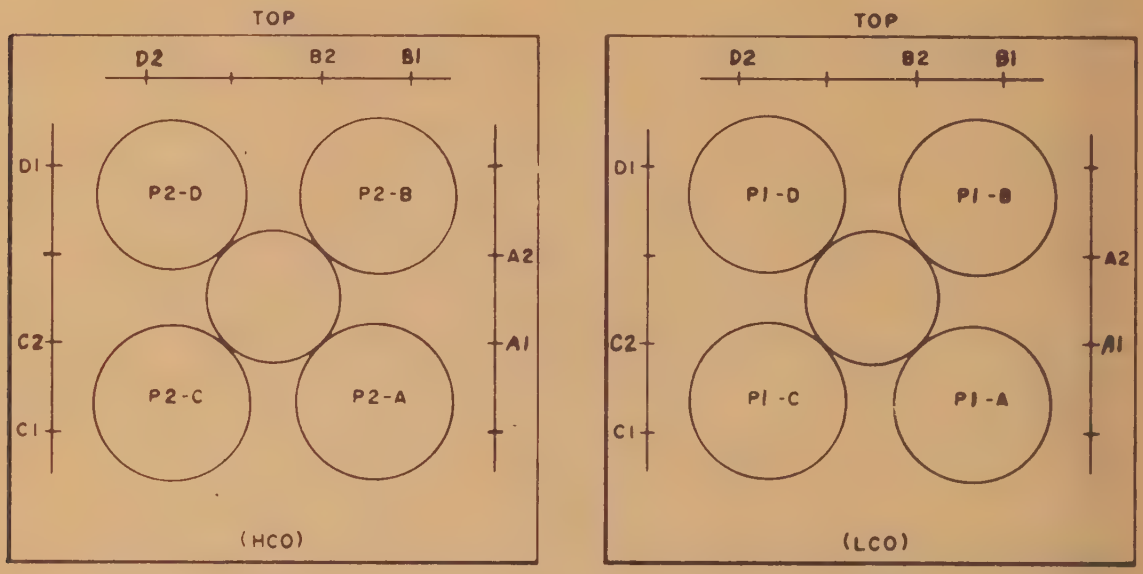


Figure 14 - REAR VIEW OF TUNING POTENTIOMETER PANELS

HCO and LCO center-of-dial (60) alignment - Align as follows:

a. Set HCO dial to 60.

b. Connect a bridge between points A1-A2 (see Figure 14A) on the terminal board. The bridge should read 25.7K ohms ±1% (resistance of potentiometer P2-A).

c. Repeat step b for points B1-B2, C1-C2, and D1-D2 (see Figure 14A). The resistance measurements should be within ±1% of those readings in Figure 15.

d. If the resistance limits of steps b and c cannot be obtained, adjust the HCO pot control to see if all measurements fall within the limits of Fig. 15 at one setting. If they do, loosen the HCO dial, slip dial to 60 and tighten. If all the pot resistances do not fall within limits at one setting, loosen the gear on the pot that is off, and readjust until it falls within limits.

e. Set LCO dial to 60.

f. Repeat steps b through c, but refer to Figure 14B. Slip LCO dial as required to fall within limits of Figure 15. Adjust individual pot as described in step d if necessary.

HCO POT. RESISTANCES*		LCO POT. RESISTANCES*	
Connect bridge across	Should read (ohms ±1%)	Connect bridge across	Should read (ohms ±1%)
A1-A2	25.7K	A1-A2	26.5K
B1-B2	28.0K	B1-B2	24.8K
C1-C2	25.7K	C1-C2	26.5K
D1-D2	28.0K	D1-D2	24.8K

*All resistance values given include the fixed trimming resistor associated with each potentiometer. All resistance values should be measured on a bridge capable of reading to at least 1% accuracy.

Figure 15 - TABLE OF HCO AND LCO POTENTIOMETER RESISTANCE MEASUREMENTS

2. ADJUSTING TRIM RESISTANCES OF TUNING POTENTIOMETERS.

When the high and low ends of the HCO and LCO dials do not calibrate with respect to the center-of-dial (60) position during the detailed test procedures (see Figure 17), refer to Figure 16 for adjustment of trim resistances for the appropriate tuning potentiometers P1 or P2.

3. DETAILED TEST PROCEDURE

a. General

(1) All dc voltage measurements are to be made with a VTVM, and are made with respect to ground (chassis), unless otherwise specified.

(2) All measurements are made with a line voltage of 115 volts having less than 1% distortion.

(3) Give the instrument a thorough visual inspection, looking particularly for oil leaks, discoloration of the chassis, component panels, or components, and loose or broken wires, poor solder connections, etc.

(4) Check that all tubes are seated firmly in the correct sockets and that all heaters light.

(5) Check operation of POWER switch.

Condition when filter dial is adjusted for 180° phase shift*		Increase or decrease trim resistance as indicated below							
		LCO potentiometers P1-A, B, C, D				HCO potentiometers P2-A, B, C, D			
		Low end of dial		High end of dial		Low end of dial		High end of dial	
Dial Reading	Output Amplitude	De-crease	In-crease	De-crease	In-crease	De-crease	In-crease	De-crease	In-crease
OK	LOW	R13	R20	R14	R21	R56	R52	R55	R51
		R27	R34	R28	R35	R60	R66	R59	R65
OK	HIGH	R20	R13	R21	R14	R52	R56	R51	R55
		R34	R27	R35	R28	R66	R60	R65	R59
LOW	LOW		R20, R34		R21, R35		R52, R66		R51, R65
HIGH	LOW	R13, R27		R14, R28		R56, R60		R55, R59	
LOW	HIGH		R13, R27		R14, R28		R56, R60		R55, R59
HIGH	HIGH	R20, R34		R21, R35		R52, R66		R51, R65	
LOW	OK		R13, R20 or R27, R34		R14, R21 or R28, R35		R52, R56 or R60, R66		R51, R55 or R59, R65
HIGH	OK	R13, R20 or R27, R34		R14, R21 or R28, R35		R52, R56 or R60, R66		R51, R55 or R59, R65	

*This is described in detail in the calibration of the LCO and HCO dials of the detailed test procedure (see Figure 17). The dial should agree with the input frequency when the phase shift is 180°, and the filter output amplitude should be attenuated -3 db from the nominal pass band gain when the phase shift is 180°.

Figure 16 - TABLE OF TRIM RESISTOR ADJUSTMENTS FOR TUNING POTENTIOMETERS

(6) Check that wires do not touch the gears and that the dials rotate smoothly.

(7) If the high and low ends of the HCO and LCO dials do not calibrate (see Figure 17), refer to Figure 16 for adjustment of trim resistances for the appropriate tuning potentiometers P1 or P2. If further tests show discrepancies, refer to Section V.

b. Test Equipment Required

Audio Oscillator - capable of supplying at least 10 volts rms from 10 cps to 200 kc with frequency calibration good to better than ±2% and distortion less than 1%. (Frequency may be checked with a good frequency counter).

A-C millivoltmeter - reading from 10 mv full scale to 10 volts (rms) full scale. (db scale desirable).

Oscilloscope - having direct coupled horizontal and vertical amplifiers with equal phase characteristics to at least 2 kc. H. P. type 120A (10 CM scale) or equivalent.

Vacuum tube voltmeter - reading to 500 volts dc. Do not use this instrument for ac signal voltage measurements.

A-C voltmeter - to measure line voltage.

c. Voltage Measurements

(1) Voltage measurement - B plus.
Read dc voltage on pin #1 of V8 (12AU7).
Tolerance: +250 to +290 volts

(2) Voltage measurement - input amplifier operating point.
Read dc voltage on pin #1 of V1 (12AT7).
Tolerance: +140 to +180 volts

(3) Voltage measurement - input amplifier operating point.
Read dc voltage on pin #6 of V1 (12AT7).
Tolerance: +90 to +130 volts

(4) Voltage measurement - OUTPUT dc level.
Read dc voltage across OUTPUT terminals.
Tolerance: zero to plus 0.15 volts
If incorrect, check output circuit and capacitors C48 and C49.

d. Test Procedures - Figure 17 contains detailed test procedures to check Filter performance. The procedures are to be performed in the given order (1 through 39). Throughout the procedures, "low cut-off" is abbreviated "LCO" and "high cut-off" is abbreviated "HCO".

Figure 17

DETAILED TEST PROCEDURE

ITEM	CHECKS TO BE MADE	FREQUENCY SETTING				INPUT SIGNAL		PROCEDURES
		LCO Dial	LCO Mult.	HCO Dial	HCO Mult.	Voltage (volts)	Freq. (cps)	
1	Overall operation	19	X1	210	X100	5.0	600	Check for 600 cps gain. Output signal should be 4.5 to 5.5 volts.
2	Output impedance	19	X1	210	X100	5.0	600	Connect a 510 ohm resistor across the OUTPUT terminals. Output signal should be 2.25 to 2.75.
3	Corner peaking - HIGH cut-off frequency	60	X1	60	X100	5.0	300	Read output signal in db. Switch HCO frequency multiplier to the X10 position. Read new value of output signal in db. Tolerance: zero to +1.5 db change from first reading.
4	Corner peaking - LOW cut-off frequency	60	X1	60	X100	5.0	1200	Read output signal in db. Switch LCO frequency multiplier to the X10 position. Read new value of output signal in db. Tolerance: zero to +1.5 db change from first reading.
5	Overload Amplitude	190	X1	210	X10	--	600	Set oscillator amplitude just below point at which scope begins to show distortion. Output signal should be greater than 7 volts and not distorted.

ITEM	CHECKS TO BE MADE	FREQUENCY SETTING				INPUT SIGNAL		PROCEDURES
		LCO Dial	LCO Mult.	HCO Dial	HCO Mult.	Voltage (volts)	Freq. (cps)	
6	Leakage of input coupling capacitor	190	X1	210	X10	5.0	600	Connect the oscillator to the Filter INPUT through a 1 mfd capacitor which has a leakage resistance of at least 100 megohms. Connect the top Filter INPUT terminal to pin #1 of V8 (12AU7) in the Filter (plus 270 volts) through a 1 megohm resistor. Set oscillator amplitude just below point at which scope begins to show distortion. Tolerance: Output signal must be greater than 5.0 volts. Note: An external source of plus 270 volts may be used for this step. Allow ample time for the capacitors to charge.
7	Gain change vs. LCO tuning	190-19	X1	210	X1000	5.0	2000	Rotate LCO dial slowly from 190 to 19. Observe any changes in output voltage. Tolerance: ±0.5 db.
8	Gain change vs. LCO band switching	19	X1	210	X1000	5.0	100KC	Switch LCO frequency multiplier successively to all four positions. Observe any changes in output voltage. Tolerance: ±0.5 db. If out of tolerance, R10 may be decreased if Gain increases with band switching, or R75 may be added or adjusted if Gain decreases with band switching.

DETAILED TEST PROCEDURES (Cont.)

ITEM	CHECKS TO BE MADE	FREQUENCY SETTING				INPUT SIGNAL		PROCEDURES
		LCO Dial	LCO Mult.	HCO Dial	HCO Mult.	Voltage (volts)	Freq. (cps)	
9	Filter gain at upper frequency limit	19	X1	210	X1000	5.0	200KC	Output signal should be greater than 1.0 volts.
10	Filter gain at lower frequency limit	19	X1	210	X1	5.0	20	Output signal should be greater than 1.0 volts.
11	Output hum and noise	30	X1	120	X1	Short circuit	--	Short Filter INPUT using a short lead. Use shielded cables. Shield bottom of Filter chassis, if necessary. Adjust control on rear of chassis labeled "Hum Adjust" for minimum reading. Tolerance: Noise signal should be less than 200 microvolts.
12	10 cps maximum attenuation below pass-band frequency	200	X1000	200	X1000	5.0	10	Output signal should be less than 0.005 volt.
13	20KC maximum attenuation below pass-band frequency	200	X1000	200	X1000	5.0	20KC	Output signal should be less than 0.005 volt.
14	20KC maximum attenuation above pass-band frequency	200	X10	200	X10	5.0	20KC	Output signal should be less than 0.005 volt.

ITEM	CHECKS TO BE MADE	FREQUENCY SETTING				INPUT SIGNAL		PROCEDURES
		LCO Dial	LCO Mult.	HCO Dial	HCO Mult.	Voltage (volts)	Freq. (cps)	
15	Test oscilloscope phase shift at 1800 cps	--	--	--	--	--	--	Set oscillator for 5.0 volts at 1800 cps. Connect scope horizontal input to the oscillator output and adjust scope for a sweep 20 divisions wide. Remove scope horizontal input. Connect scope vertical input to the oscillator output. Adjust scope for a line 20 divisions high. Connect both horizontal and vertical inputs to the oscillator and check for equal horizontal and vertical phase shift in the scope amplifier by noting a completely closed ellipse (straight line) at about a 45 degree angle.
	Note: For calibration steps 16 through 29, connect a 1500 ohm resistor across the filter OUTPUT terminals.							
16	Phase calibration of LCO dial at 600 cps	60	X10	210	X1000	5.0	600	Connect scope vertical input to pin #8 of V4 (12AX7) through a large capacitor to remove dc present at this point. Capacitor must be large enough so that phase shift of scope is not altered at 250 cps. Connect scope horizontal input to the output of the oscillator. Adjust LCO dial to close the ellipse at about a 135 degree angle. Tolerance: 56.4 to 63.6 If out of tolerance, reset dial by loosening the set-screws.

DETAILED TEST PROCEDURE (Cont.)

ITEM	CHECKS TO BE MADE	FREQUENCY SETTING				INPUT SIGNAL		PROCEDURES
		LCO Dial	LCO Mult.	HCO Dial	HCO Mult.	Voltage (volts)	Freq. (cps)	
17	3db attenuation calibration of LCO dial at 600 cps	60	X10	210	X1000	5.0	600	Switch low cut-off frequency multiplier to the X1 position. With scope vertical input on pin #8 of V4, adjust oscillator output for a scope vertical deflection of exactly 20 divisions. Return low cut-off frequency multiplier to the X10 position. Adjust LCO dial for a scope vertical deflection of 14 divisions (minus 3 db). Tolerance: 56.4 to 63.6 (Record this reading for use in step 38.) Note: The ac VTVM may be used for this and subsequent measurements instead of the scope, if desired.
18	Phase calibration of LCO dial at 250 cps	25	X10	210	X1000	5.0	250	Proceed as in step 16, assuming that the scope calibration and phase shift have not changed. Tolerance: 23.5 to 26.5
19	3db attenuation calibration of LCO dial at 250 cps	25	X10	210	X1000	5.0	250	Proceed as in step 17, switching the LCO frequency multiplier to the X1 position to set the scope; returning to the X10 position for the final reading. Tolerance: 23.5 to 26.5
20	Phase calibration of LCO dial at 1800 cps	180	X10	210	X1000	5.0	1800	Proceed as in step 16, assuming that the scope calibration and phase shift have not changed. Tolerance: 170 to 190

ITEM	CHECKS TO BE MADE	FREQUENCY SETTING				INPUT SIGNAL		PROCEDURES
		LCO Dial	LCO Mult.	HCO Dial	HCO Mult.	Voltage (volts)	Freq. (cps)	
21	3db attenuation calibration of LCO dial at 1800 cps	180	X10	210	X1000	5.0	1800	Proceed as in step 17, switching the LCO frequency multiplier to the X1 position to set the scope and returning to the X10 position for the final reading. Tolerance: 170 to 190
22	3db attenuation calibration of LCO dial at 60 on the dial for all bands	60	--	210	X1000	2.5	--	Follow the procedure of step 17 for the last three positions of the LCO multiplier switch. On each of these bands, adjust the scope with the multiplier switch in the next lower position, then restore the multiplier switch so that the LCO frequency is equal to the oscillator frequency and adjust the LCO dial for a vertical deflection of 14 divisions. For the first position (X1) of the LCO multiplier switch, it will be necessary to adjust the scope at an oscillator frequency of 600 cps with the LCO frequency multiplier on X1 and then reduce the oscillator frequency to 60 cps. The oscillator output voltage should be checked with the scope to make certain that the amplitude does not change at 60 cps. Adjust the LCO dial for a vertical deflection of 14 divisions. Tolerance: (all bands) 56.4 to 63.6 (Cont.)

DETAILED TEST PROCEDURE (Cont.)

ITEM	CHECKS TO BE MADE	FREQUENCY SETTING				INPUT SIGNAL		PROCEDURES
		LCO Dial	LCO Mult.	HCO Dial	HCO Mult.	Voltage (volts)	Freq. (cps)	
22 (Cont.)								In addition to checking 60 on the Dial on all bands, 200 on the Dial, with multiplier set on X1000, (200 kc), should be checked. This can be checked in the same manner as 60 kc is checked, except that the Oscillator Frequency is set at 200 kc. If the dial is out of Tolerance, C53A (8-60 uuf) can be adjusted to compensate for error.
23	Phase calibration of HCO dial at 600 cps	25	X1	60	X10	5.0	600	Connect scope horizontal input to the oscillator output and adjust scope for a sweep 20 divisions wide. Remove scope horizontal input and connect vertical input to the oscillator output. Adjust scope for a line 20 divisions high. Phase shift of scope has been checked in step 15. Connect horizontal input to Pin 8 of V4 and vertical input to the Filter OUTPUT. Adjust HCO dial to close the ellipse at about 135 degrees. Tolerance: 56.4 to 63.6 If out of tolerance, reset dial by loosening the set-screws.

DETAILED TEST PROCEDURES (Cont.)

ITEM	CHECKS TO BE MADE	FREQUENCY SETTING				INPUT SIGNAL		PROCEDURES
		LCO Dial	LCO Mult.	HCO Dial	HCO Mult.	Voltage (volts)	Freq. (cps)	
24	3db attenuation calibration of HCO dial at 600 cps	25	X1	60	X10	5.0	600	Switch high cut-off frequency multiplier to the X100 position, Adjust oscillator output for a scope vertical deflection of exactly 20 divisions. Return high cut-off frequency multiplier to the X10 position. Adjust the HCO dial for a scope vertical deflection of 14 divisions (minus 3 db). Tolerance: 56.4 to 63.6 (Record this reading for use in step 39).
25	Phase calibration of HCO dial at 250 cps	25	X1	25	X10	5.0	250	Proceed as in step 23, assuming that the scope calibration and phase shift have not changed. Tolerance: 23.5 to 26.5.
26	3db attenuation calibration of HCO dial at 250 cps	25	X1	25	X10	5.0	250	Proceed as in step 24, switching the HCO frequency multiplier to the X100 position to set the scope, returning to the X10 position for the final reading. Tolerance: 23.5 to 26.5.
27	Phase calibration of HCO dial at 1800 cps	25	X1	180	X10	5.0	1800	Proceed as in step 23, assuming that the scope calibration and phase shift have not changed. Tolerance: 170 to 190
28	3db attenuation calibration of HCO dial at 1800 cps	25	X1	180	X10	5.0	1800	Proceed as in step 24, switching the HCO frequency multiplier to the X10 position to set the scope; returning to the X1 position for the final reading. Tolerance: 170 to 190

DETAILED TEST PROCEDURES (Cont.)

ITEM	CHECKS TO BE MADE	FREQUENCY SETTING				INPUT SIGNAL		PROCEDURES
		LCO Dial	LCO Mult.	HCO Dial	HCO Mult.	Voltage (volts)	Freq. (cps)	
29	3db attenuation calibration of HCO dial at 60 on dial for all bands	25	X1	60	--	5.0	--	Follow the procedure of step 24 for the first three positions of the HCO multiplier switch. On each of these bands adjust the scope with the multiplier switch in the next higher position, then restore the multiplier switch so that the HCO frequency is equal to the oscillator frequency and adjust the HCO dial for a vertical deflection of 14 divisions. For the last position (X1000) of the HCO multiplier switch, it will be necessary to adjust the scope at an oscillator frequency of 6000 cps with HCO frequency multiplier on X1000 and then increase the oscillator frequency to 60 kc. The oscillator output voltage should be checked with the scope to make certain that the amplitude does not change at 60 kc. Adjust the HCO dial for a vertical deflection of 14 divisions. Tolerance: (All bands) 56.4 to 63.6. In addition to checking 60 on the Dial on all bands, 200 on the Dial, with multiplier set on X1000, (200 kc), should be checked. This can be checked in the same manner as 60 kc is checked, except that the oscillator frequency is set at 200 kc. if the Dial is out of Tolerance, C54 can be adjusted to compensate for error. Note: Remove 1500 ohms resistor from filter OUTPUT terminals for remaining tests.

DETAILED TEST PROCEDURE (Cont.)

ITEM	CHECKS TO BE MADE	FREQUENCY SETTING				INPUT SIGNAL		PROCEDURES
		LCO Dial	LCO Mult.	HCO Dial	HCO Mult.	Voltage (volts)	Freq. (cps)	
30	Gain at 22KC for narrowest band setting	22	X1000	22	X1000	5.0	22,000	Output signal should be between 1.50 and 3.50 volts.
31	LCO corner peaking at 22KC in X1000 position.	22	X1000	66	X1000	5.0	22,000	Output signal should be between 2.5 and 5.0 volts.
32	HCO corner peaking at 22 KC in X1000 position.	70	X100	22	X1000	5.0	22,000	Output signal should be between 2.5 and 5.0 volts.
33	High-pass filter components in X1000 position	66	X1000	22	X1000	5.0	22,000	Output signal should be between 0.018 and 0.066 volt.
34	Pass-band gain for the following Frequency Settings and Input Signals	70 20 20 20	X100 X100 X10 X1	66 200 200 200	X1000 X100 X10 X1	5.0 5.0 5.0 5.0	22,000 6,000 600 60	For each of the Frequency Settings and Input Settings, the output signal should be between 4.5 and 6.5 volts.
35	Low-pass filter section components for the following Frequency Settings and Input Signals	60 60 60 60	X1 X10 X100 X1000	20 20 20 20	X1 X10 X100 X1000	5.0 5.0 5.0 5.0	60 600 6,000 60,000	For each of the Frequency Settings and Input Settings, the output signal should be between 0.025 and 0.07 volt.

DETAILED TEST PROCEDURE (Cont.)

ITEM	CHECKS TO BE MADE	FREQUENCY SETTING				INPUT SIGNAL		PROCEDURES
		LCO Dial	LCO Mult.	HCO Dial	HCO Mult.	Voltage (volts)	Freq. (cps)	
CABINET CHECK - Install the instrument in its cabinet and leave it turned ON for a 24 hour period. Then perform Steps 36 thru 39.								
36	Overall operation	19	X1	210	X100	5.0	600	Output signal should be between 4.5 and 5.5 volts.
37	Filtering action of LCO and HCO sections	19	X10	210	X10	5.0	600	First turn LCO dial to 210 and note that output signal is greatly attenuated. Turn both dials to 19 and observe that signal is still greatly attenuated.
38	3db attenuation calibration of LCO dial at 600 cps	60	X10	210	X1000	5.0	600	Repeat step 17, measuring at filter OUTPUT terminals instead of pin #8 of V4 (12AX7). Results should agree with previous reading in step 17 within 3%.
39	3db attenuation calibration of HCO dial at 600 cps	25	X1	60	X10	5.0	600	Repeat step 24. Results should agree with previous reading in step 24 within 3%.

SECTION VII - SERVICE AND WARRANTY

KROHN-HITE Instruments are designed and manufactured in accordance with sound engineering practices and should give long trouble-free service under normal operating conditions. If your Band-Pass Filter fails to provide satisfactory service and you are unable to locate the source of trouble, write to our Service Department giving all the information available concerning the failure.

Do not return the instrument without our written authorization, for in most cases we will be able to supply you with the information necessary to repair the Band-Pass Filter and thus avoid the transportation problems and costs. When it becomes necessary to return the instrument to our Factory, kindly pack it carefully and ship it to us via Express, prepaid.

KROHN-HITE Instruments are conservatively designed to provide continuous reliable service under normal laboratory conditions. The material and workmanship in every new instrument manufactured by Krohn-Hite is guaranteed for one year from the date of shipment to the original purchaser. Any instrument developing defects during this period will be repaired or replaced without charge when the failure is the result of defective material or workmanship. This warranty does not apply to electron tubes, fuses, batteries, transistors and other semiconductor devices.

KROHN-HITE CORPORATION reserves the right to make design changes at any time without incurring any obligation to incorporate these changes in instruments previously purchased.

Schematic Symbol	Description			Qty	Mfg.	Mfg Part No.
R-1	22K	10%	1/2W	3	A-B	EB-2231
R-2	680K	5%	1/2W	1	A-B	EB-6845
R-3	68K	5%	1/2W	1	A-B	EB-6835
R-4	1.5K	5%	1/2W	1	A-B	EB-1525
R-5	1M	10%	1/2W	3	A-B	EB-1051
R-6	100 OHM	20%	1/2W	14	A-B	EB-1012
R-7	82K	5%	1/2W	1	A-B	EB-8235
R-8	1K	5%	1/2W	1	A-B	EB-1025
R-9	Same as R-6					
R-10	Fact. Adj. Approx. 22K				A-B	
R-11	3K	5%	1/2W	1	A-B	EB-3025
R-12	8.2K	5%	1/2W	1	A-B	EB-8225
R-13	Part of Pot 1 Assembly					*
R-14	Part of Pot 1 Assembly					*
R-15	Same as R-6					
R-16	7.5K	5%	1/2W	2	A-B	EB-7525
R-17	560 OHM	5%	1/2W	2	A-B	EB-5615
R-18	Same as R-6					
R-19	Same as R-5					
R-20	Part of Pot 1 Assembly					*
R-21	Part of Pot 1 Assembly					*
R-22	6.2M	5%	1/2W	2	A-B	EB-6255
R-23	3.9M	5%	1/2W	1	A-B	EB-3955
R-24	Same as R-6					
R-25	1.3K	5%	1/2W	2	A-B	EB-1325
R-26	22K	10%	1W	2	A-B	GB-2231
R-27	Part of Pot 1 Assembly					*
R-28	Part of Pot 1 Assembly					*
R-29	Same as R-6					
R-30	Same as R-16					
R-31	Same as R-17					
R-32	Same as R-6					
R-33	Same as R-5					
R-34	Part of Pot 1 Assembly					*
R-35	Part of Pot 1 Assembly					*
R-36	Same as R-22					
R-37	Same as R-22					
R-38	Same as R-6					
R-39	Same as R-25					
R-40	Same as R-26					
R-45	Same as R-6					
R-46	Same as R-6					
R-47	10M	5%	1/2W	1	A-B	EB-1065
R-48	560K	5%	1/2W	1	A-B	EB-5645
R-50	22M	10%	1/2W	1	A-B	EB-2261
R-51	Part of Pot 2 Assembly					*
R-52	Part of Pot 2 Assembly					*
R-53	Same as R-6					

Schematic Symbol	Description	Qty.	Mfg.	Mfg. Part No.
R-54	27K 10% 1W	4	A-B	GB-2731
R-55	Part of Pot 2 Assembly			*
R-56	Part of Pot 2 Assembly			*
R-57	Same as R-6			
R-58	Same as R-54			
R-59	Part of Pot 2 Assembly			*
R-60	Part of Pot 2 Assembly			*
R-61	6.8M 5% 1/2W	1	A-B	EB-6855
R-62	Same as R-6			
R-63	4.7M 5% 1/2W	1	A-B	EB-4755
R-64	Same as R-54			
R-65	Part of Pot 2 Assembly			*
R-66	Part of Pot 2 Assembly			*
R-67	Same as R-6			
R-68A	12K 10% 1/2W	1	A-B	HB-1231
R-69	Same as R-1			
R-70	Same as R-1			
R-71	470 OHM 10% 1/2W	1	A-B	EB-4711
R-72	470K 10% 1/2W	1	A-B	EB-4741
R-73	Fact. Adj. Approx. 1.2K		A-B	
R-74	2K 5% 1/2W	1	A-B	EB-2025
R-75	Fact. Adj. Approx. 51K		A-B	
R-76	150K 10% 1/2W	1	A-B	EB-1541
R-77	500 OHM Variable Resistor	1	CTS	JF7516
C-1	0.1MF 20% 400V Paper	4	SP	67P10304
C-2	Same as C-1			
C-4	51MMF ±1% 500V Mica	2	EL	CM19C510F
C-5	910MMF ±1% 500V Mica	1	EL	CM19C911F
C-6	**.01MF ±5% 100V Paper	8	KH	BCM101
C-7	**.1MMF ±5% 100V Paper	8	KH	BCM100
C-8	Same as C-1			
C-9	120MMF ±1% 500V Mica	1	EL	CM19C121F
C-10	**.001MF ±5% 100V Paper	7	KH	BCM102
C-11	Same as C-6			
C-12	Same as C-7			
C-13	.1MF ±20% 200V Paper	4	SP	109P10402
C-14	Same as C-4			
C-15	Same as C-10			
C-16	Same as C-6			
C-17	Same as C-7			
C-18	Same as C-1			
C-19	95MMF ±1% 500V Mica	1	EL	CM19C950F
C-20	Same as C-10			
C-21	Same as C-6			
C-22	Same as C-7			
C-23	Same as C-13			
C-24	Same as C-13			
C-25	.1MF ±20% 400V Paper	1	SP	67P10404

SECTION VIII - PARTS LIST

Schematic Symbol	Description	Qty.	Mfg.	Mfg. Part No.
C-26	2 x 40MF 450V Electrolytic	2	SP	17D15
C-27	1/2 C-26			
C-28	.1MF 20% 600V Paper	2	SP	73P10406
C-29	Same as C-28			
C-30	.01MF ±20% 500V Ceramic	1		Type 29C
C-31	91MMF ±1% 500V Mica	2	EL	CM19C910F
C-32	Same as C-10			
C-33	Same as C-6			
C-34	Same as C-7			
C-35	39MMF ±1% 500V Mica	1	EL	CM19C390F
C-36	Same as C-10			
C-37	Same as C-6			
C-38	Same as C-7			
C-39	Same as C-31			
C-40	Same as C-10			
C-41	Same as C-6			
C-42	Same as C-7			
C-43	Same as C-13			
C-44	75MMF ±1% 500V Mica	1	EL	CM19C075F
C-45	Same as C-10			
C-46	Same as C-6			
C-47	Same as C-7			
C-48	Same as C-26			
C-49	1/2 C-48			
C-50	.001MF ±20% 400V Paper	1	SP	67P10204
C-51	1MF 20% 400V Oil Can	1	C-D	WC4100
C-52	100MMF ±10% 500V Mica	1	EL	DM19C101K
C-53	39MMF ±20% 500V Mica	1	EL	CM19C390M
C-53A	8-60MMF TRIMMER	1	AR	404
C-54	90-400MMF TRIMMER	1	AR	429
P1a, b, c, d	Part of Pot 1 Assembly			
P2a, b, c, d	Part of Pot 1 Assembly			
T-1	Power Transformer	1	KH	P-100-14
L-1	20 HY Choke	1	KH	C-100-6A
F-1	FUSE LAMP SLO-BLO	1	BU	MDL 1
S-1	BAND SWITCH	2	KH	PA277-355
S-2	Same as S-1			
S-3	Power Switch SPST Toggle	1	C-H	828K16
	Pilot Light	1	GE	#51
	Binding Posts Red	2	SU	DF30RC
	Binding Posts Black	2	SU	DF30BC
	Power Cord 5 Ft.	1	KH	KH4018

SECTION VIII - PARTS LIST

Schematic Symbol	Description	Qty.	Mfg.	Mfg. Part No.
V-1	12AT7 Tube	6	GE	
V-2	Same as V-1			
V-3	Same as V-1			
V-4	Same as V-1			
V-5	Same as V-1			
V-6	6X5 Tube	1	RCA	
V-7	6AU5 Tube	1	RCA	
V-8	Same as V-1			
V-9	6BK7B	1	RCA	

MANUFACTURER LISTING

Abbreviation	Name	Address
A-B	Allen-Bradley Company	Milwaukee 4, Wisconsin
AR	Arco Electronics Inc.	New York 13, New York
BU	Bussman Manufacturing Co.	St. Louis, Mo.
C-D	Cornell Dubilier Elec. Co.	South Plainfield, N. J.
C-H	Cutler-Hammer Inc.	Milwaukee, Wisconsin
CTS	Chicago Telephone Supply Corp.	Elkhart, Indiana
EL	El-Menco	Willimantic, Conn.
GE	General Electric Co.	Schenectady, New York
KH	Krohn-Hite Corporation	Cambridge 39, Mass.
SP	Sprague Electric Company	North Adams, Mass.
SU	Superior Electric Company	Bristol, Conn.

Manufacturer's Part No. listed may not agree with Part No. found in instrument but parts shown are a direct replacement.

This Parts List applies to all instruments, starting with Serial No. 2191.

*Pot 1 and Pot 2 assemblies are non-repairable items and must be replaced with complete units, obtained from Krohn-Hite Corp.

**These capacitors have a basic tolerance of ±5%. They are selected at the factory to fall in decade steps within 2% of each other. For replacement purposes use 1% tolerance.

Figure 9 lists the voltages and resistances between the pins of each socket and ground (except as noted). The meter used for the d-c measurements was a V.T.V.M. with an impedance of 11 megohms. All measurements were made with both dials set at 200 x 1000. All voltages measured with 115 vac line. Variations of 20% may be expected.

Voltage and Resistance Chart

TUBE			PIN NUMBER								
No.	Type		1	2	3	4	5	6	7	8	9
V1	12AT7/ ECC801S	V	170	25	30	60	60	123	0	1.5	60
		R	*68K	700K	6K	480K	480K	*82K	1M	1K	480K
V2	12AT7/ ECC81	V	250	123	125	60	60	48	**	0	60
		R	*0	*82K	33K	480K	480K	*560K	22M	0	480K
V3	12AT7/ ECC81	V	120	0	1.6	60	60	240	118	120	60
		R	∞	1M	560	480K	480K	*7.5K	30K	∞	480K
V4	12AT7/ ECC81	V	250	110	126	60	60	250	100	133	60
		R	*0	3M	24K	480K	480K	*0	2.8M	24K	480K
V5	12AT7/ ECC81	V	230	125	126	60	60	126	0	1.5	60
		R	*7.5K	30K	∞	480K	480K	∞	1M	560	480K
V6	6X5-	V	-	60	320AC	-	320AC	-	60	360	
		R	-		205	-	205	-		∞	
V7	6AU5	V	**	250	250	-	330		250	330	
		R	*10M	*0	*100	-		-	*0	∞	
V8	12AT7/ ECC801S	V	250	132	132	60	60	250	128	129	60
		R	*0	30K	30K	480K	480K	*0	40K	27K	480K
V9	6922/ E88CC	V	250	84	115	60	60	250	116	118	0
		R	*0	3.5M	27K	480K	480K	*0	36K	8K	0

* These Resistances Measured to +250 Buss.
** High Impedance.

Figure 9 - Model 310-ABR-8 TABLE OF VOLTAGE AND RESISTANCES MEASUREMENTS.

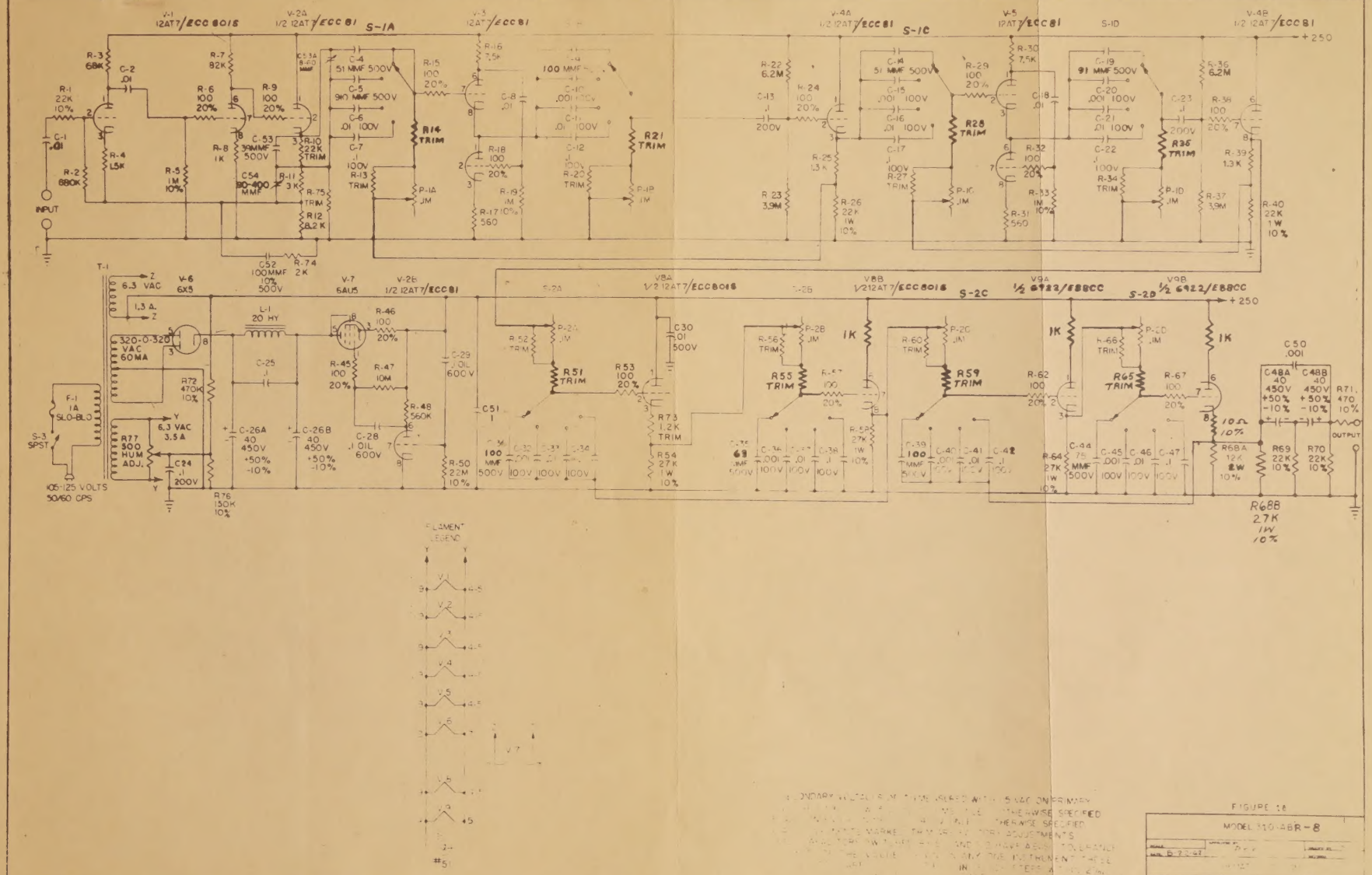


FIGURE 18

MODEL 310-48R-8

CORP

31-048

www.manualsplus.com
1006946

KROHN-HITE CORPORATION

580 Massachusetts Ave., Cambridge 39, Mass., U.S.A.

www.manualsplus.com
1000890

Printed in U.S.A. 8-62-1000